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EVALUATION OF NORMALIZATION OF AN/SQS-26 ODT CHANNEL.(U)
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TECHNICAL NOTE

EVALUATION OF NORMALIZATION OF AN/SQS-26 ODT CHANNEL (U)

by

B. C. Fowler

Submitted to
Commander
Naval Ship Systems Command
Department of the Navy
Washington, D. C. 20360
Attention: Mr. J. D. Hodges
(Code PMS-87)

17 April 1968

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1. INTRODUCTION, SUMMARY, AND CONCLUSIONS

(U) This technical note describes an evaluation of two schemes for normalizing the output of the AN/SQS-26 ODT channel. The two techniques under consideration are described ~~in Section 4 of this technical note~~ and are referred to as a mean-divider and a norm device, respectively.

(U) For this study, the ODT processor is preceded by a perfect AGC, which results in the input to the processor having a fixed level and a bandwidth which varies with reverberation-to-noise ratio, R/N. Sets of interference were generated from an interference model~~, described in Section 2,~~ for specified R/N. The interference spectrum varied from set to set as a function of R/N. However, time variations in the interference spectrum were not considered in this study.

~~(C)~~ It is shown that the rate of exceeding threshold as a function of threshold varies with R/N at the output of the mean-divider. This lack of normalization indicates that, for the ODT processor, no further investigation of the device is warranted. The rate of exceeding threshold as a function of threshold does not vary with R/N at the output of the norm device and additionally there is no degradation in signal detectability for the norm device. Although the effects of a time-varying interference spectrum have not been evaluated, the work reported here presents a strong case for the use of the norm device as a means of normalizing the ODT channel.

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2. SIMULATED DATA

2.1 INTERFERENCE MODEL

For this simulation study, input interference data were constructed from a model consisting of two components, reverberation and noise. The component of interference representing noise was Gaussian with a bandwidth of 150 Hz centered arbitrarily at 225 Hz. The power spectrum of this noise is shown in Fig. 1. The component representing reverberation was obtained by correlating wide band Gaussian noise with a 30 msec, 225 Hz CW. The correlation used a clipped reference, resulting in a non-symmetric spectrum, typical of actual sea data. The power spectrum of the reverberation appears in Fig. 2. By adding the two components in appropriate proportions, twenty-two sets of interference were generated, each set of 20 seconds duration. These sets covered R/N from -20 dB to +20 dB in 2 dB steps, reverberation alone, and noise alone. Each set of interference was normalized for constant input power. The power spectrum of the interference for R/N = 0 dB is shown in Fig. 3.

2.2 SIGNAL PLUS INTERFERENCE

Examples of signal plus interference were constructed to determine the processing gains of the ODT processor and the two modifications. The signal was an ideal rectangular CW pulse of 30 msec duration and frequency of 225 Hz. Three types of input interference were considered:

(a) noise alone,

(b) reverberation alone, and

(c) noise and reverberation equal.

Four sets of signal plus interference were generated at signal-to-interference ratios of 0,2,4, and 6 dB. Each set contained twenty signals added to independent interference.

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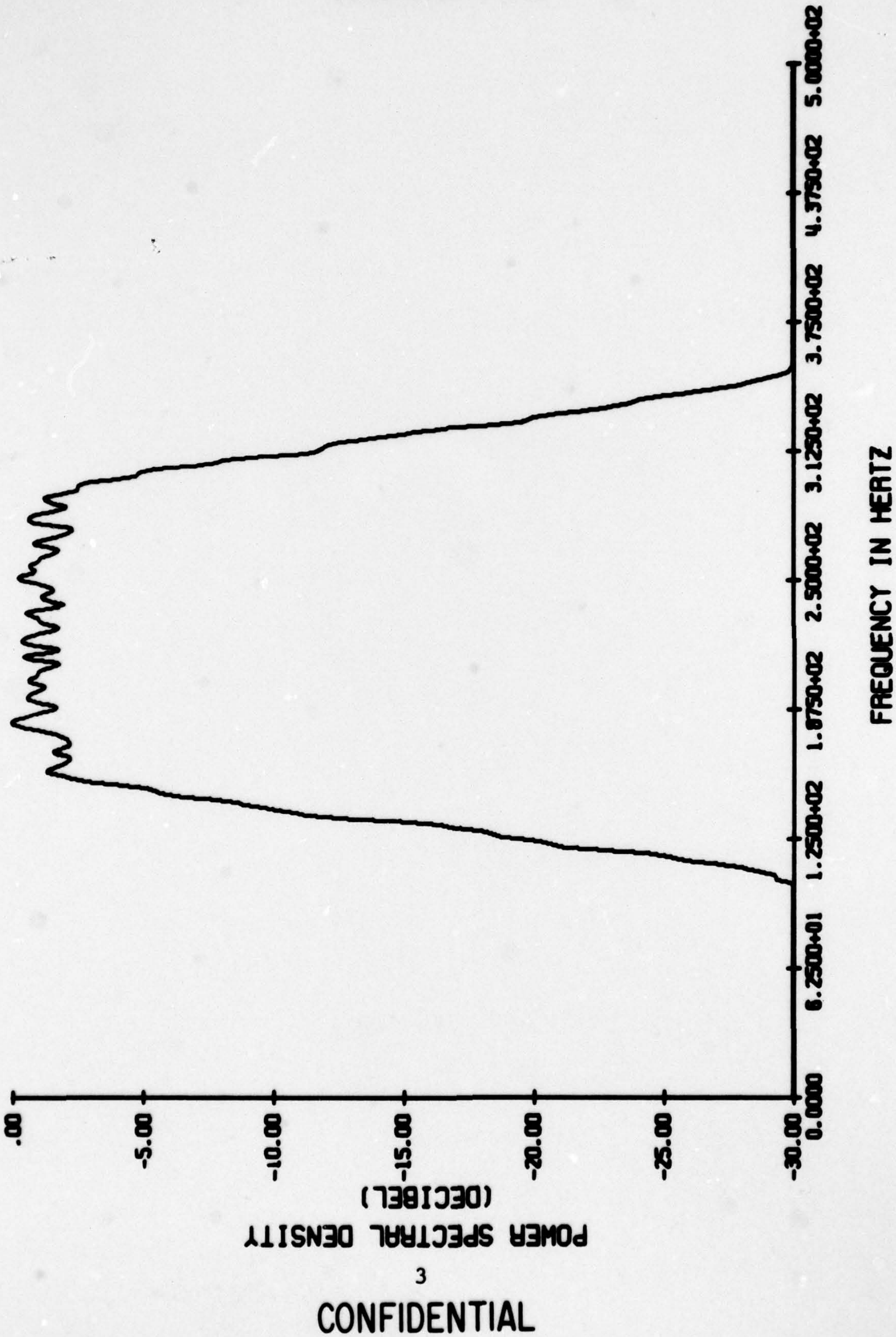

Fig. 1. Power Spectrum of 150 Hz Bandlimited Gaussian Noise (C)

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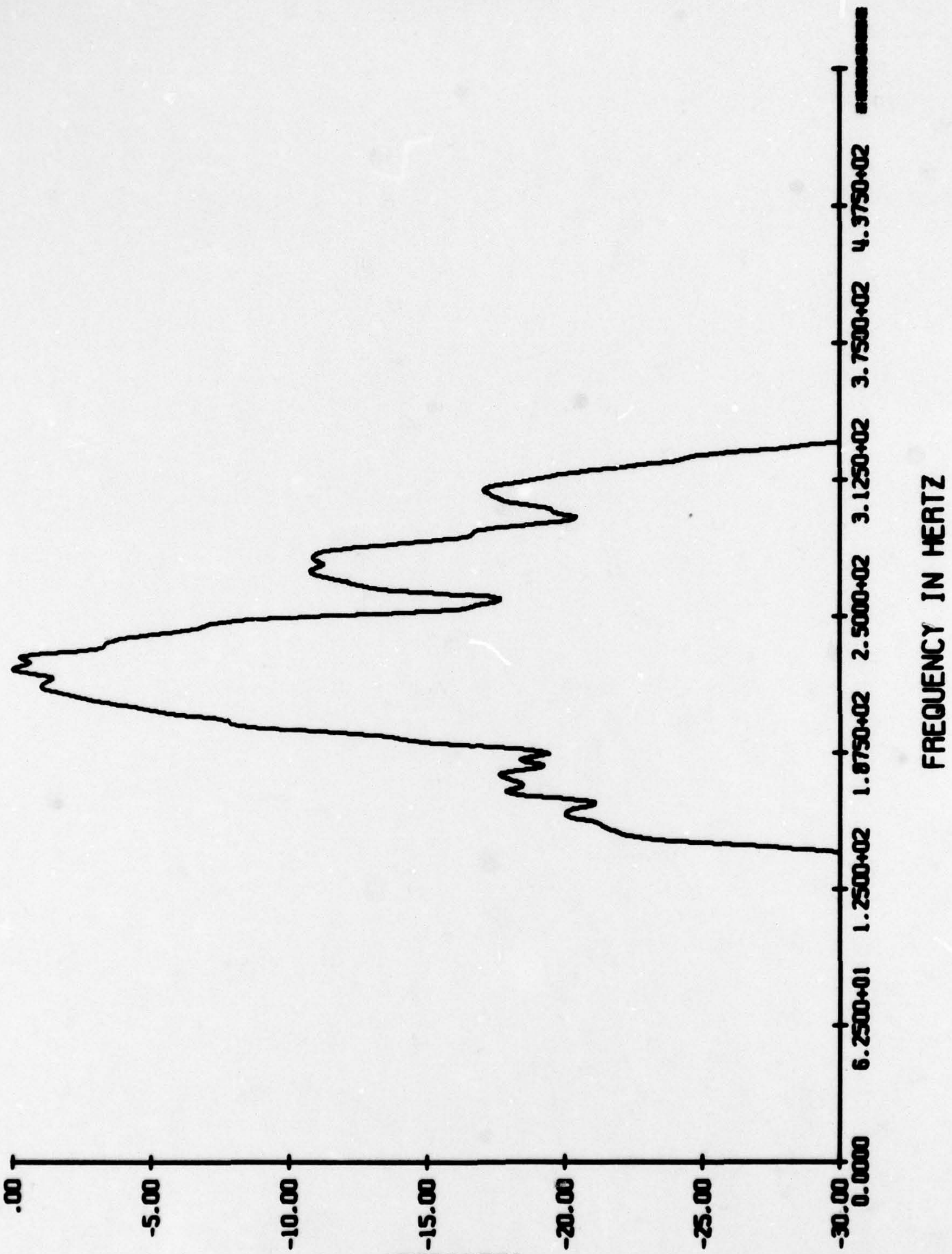

Fig. 2. Power Spectrum of Simulated Reverberation From 30 msec CW Pulse. (U)

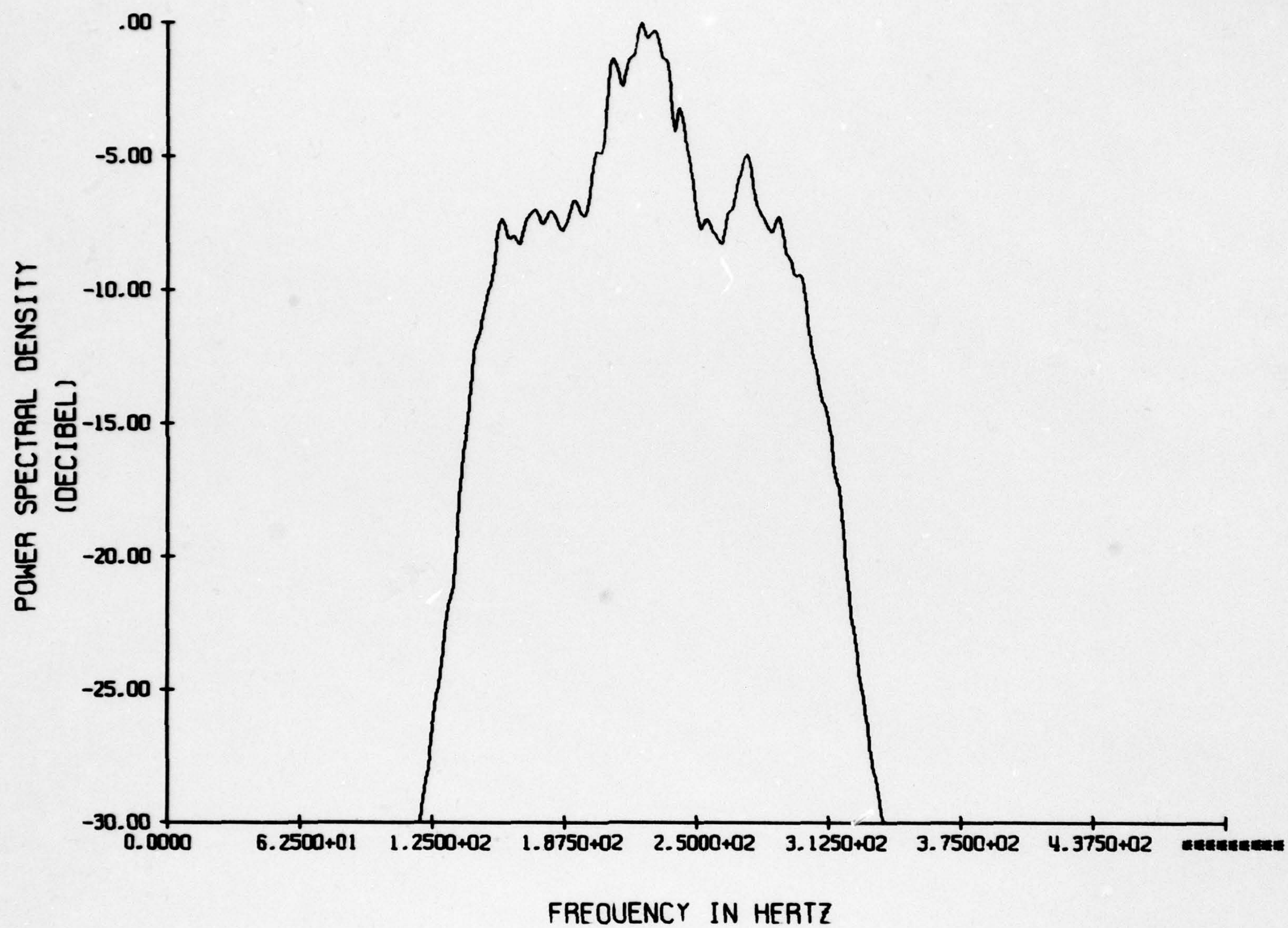

Fig. 3. Power Spectrum of Reverberation Plus Noise in Equal Parts.(U)

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3. BASE PROCESSOR AND MODIFICATIONS

(C) The ODT processor was a computer simulated full wave detector followed by a finite time perfect averager with averaging time of 30 msec. Two modifications to the base processor were evaluated as data normalization devices.

(C) The first modifcation, the mean-divider, is similar to a conventional AGC. The output of the base processor drives the mean-divider, whose output equals the instantaneous detector averager output divided by the detector averager output averaged over 600 msec.

(C) The second modification to the base processor was the norm device. The output of the detector averager drives the norm device, whose output is

$$Y_i = \frac{X_i - \overline{X}}{\sigma} , \tag{3-1}$$

where X_i is the instantaneous output of the detector averager, $\overline{X}$ is the average of the detector averager output and σ is the standard deviation of the detector averager output. The average and standard deviation of the detector averager output were computed using a gap window technique, where X_i occurred in the center of a 3 msec gap and 300 msec of data on both sides of the gap were used to compute $\overline{X}$ and σ.

4. PROCESSING METHOD AND SIMULATION RESULTS

The simulated inputs described in Section 2 were processed through the computer simulated base processor, the output of which was then passed through the mean-divider and separately, through the norm device. The outputs of the base processor and the two modifications were analyzed to determine:

(1) Output interference-to-noise ratio as a function of input R/N.

(2) Output clutter rate as a function of input R/N.

(3) Processing gain curves for reverberation alone, noise alone, and reverberation plus noise in equal parts.

4.1 OUTPUT INTERFERENCE-TO-NOISE RATIO

The variance and mean were computed for each set of interference at the output of the base processor and the two modifications. It was found that the mean was essentially constant for all R/N at each of the three outputs. The output interference-to-noise ratio I/N was computed for each input R/N by

$$\frac{I}{N} = 10 \log \frac{\sigma^2_{R+N}}{\sigma^2_N} , \qquad (4\text{-}1)$$

where σ^2_{R+N} is the variance of the output for a particular value of input R/N and σ^2_N is the variance of the output for noise alone (no reverberation added) at the input. In Fig. 4, the output I/N is plotted as a function of input R/N for the base processor, the mean-divider, and the norm device. From Fig. 4 it is seen that variations in input R/N (and consequently changes in input bandwidth) are reflected in the output interference-to-noise ratio for the base processor and the mean-divider, even though input power was held constant. The output interference-to-noise ratio for the norm device was constant to within ± 0.1 dB.

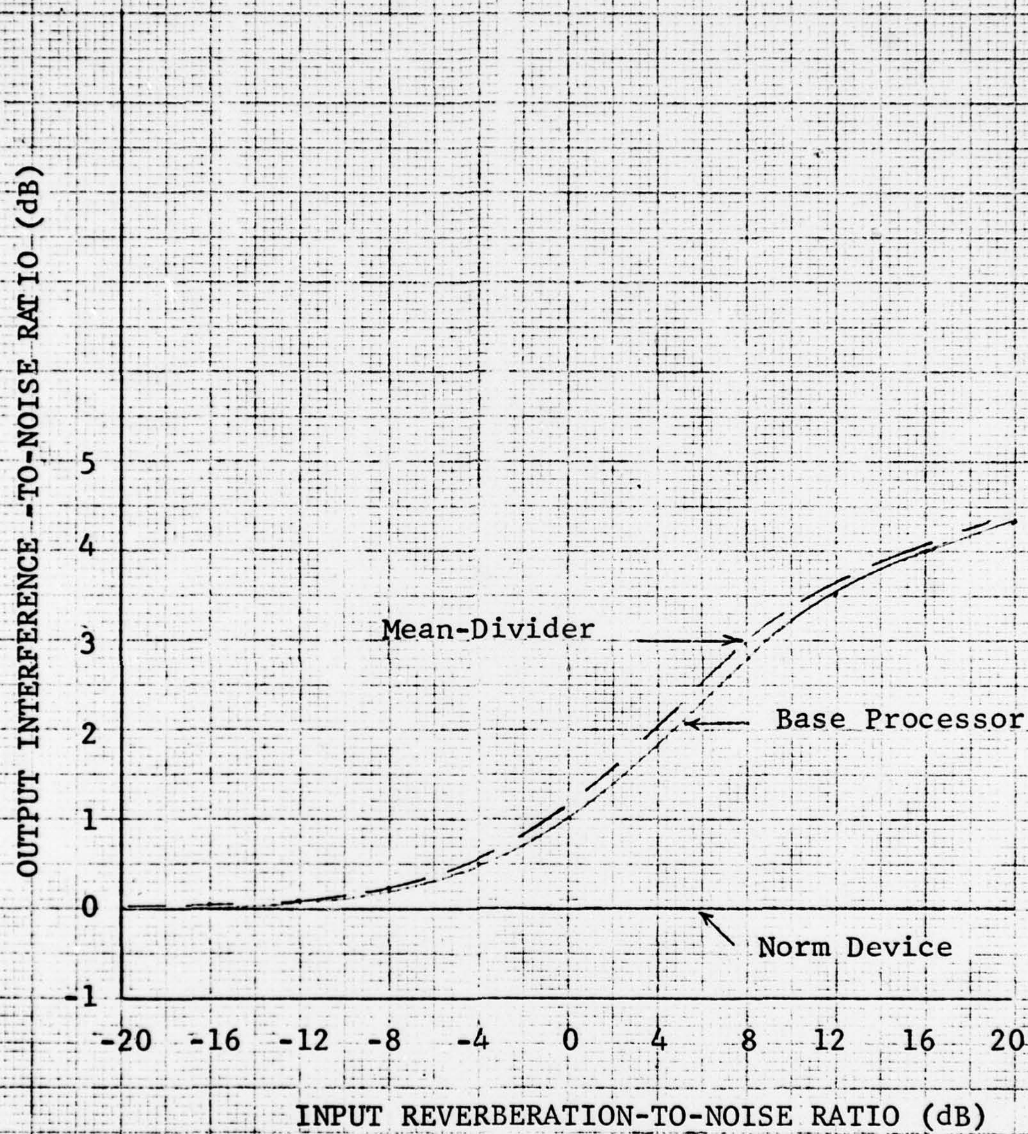

Fig. 4. Interference-to-Noise Ratio at Output of ODT Processor, Mean-Divider and Norm Device. (U)

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4.2 OUTPUT CLUTTER RATE MEASUREMENTS

(U) The results of the previous section indicate that output interference power will vary as the ODT channel input noise bandwidth changes. As a result, the mean and standard deviation of the ODT noise output will vary and tend to produce a non-uniform noise marking of the ODT display. To measure the departure from normalization introduced in this manner, calculations of threshold crossing rates at the ODT processor, mean-divider, and norm device outputs were made for various values of input R/N. The resulting curves for the ODT processor, the mean-divider, and the norm device appear in Figs. 5, 6, and 7, respectively. Several curves appear in each figure, each for a different value of input R/N. In these curves, the rate at which independent samples of the output exceed a threshold is plotted as a function of the threshold value T, where T is in units of the 150 Hz output standard deviation relative to the 150 Hz output mean. The values of threshold crossing rate R(T) are approximated by[1]

$$R(T) = P(T) \cdot N, \tag{4-2}$$

where P(T) is the probability that a single independent output local peak exceeds the threshold value T, and N is the number of independent local peaks occurring per second.

(C) Figures 5 and 6 indicate that the mean-divider is not effective in reducing the variations in ODT channel output clutter rate. Figures 5 and 7 indicate that the norm device is effective, since the clutter rate at the output of the norm device is essentially identical for any input R/N.

[1] A COMPARISON OF THE PERFORMANCE OF SEVERAL SIGNAL PROCESSORS, TRACOR Document No. 66-203-U, March, 1966.

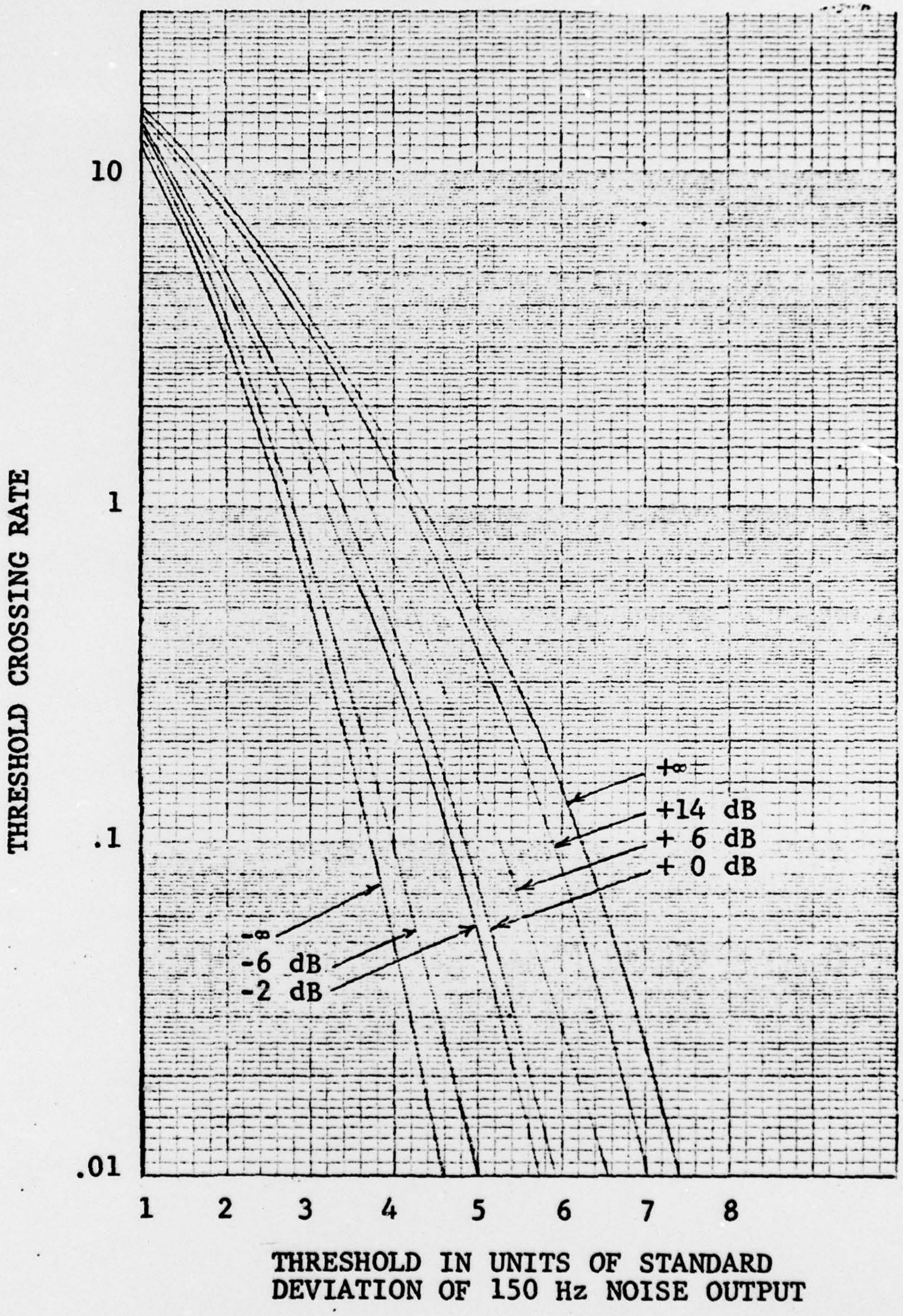

Fig. 5. ODT Processor Output Clutter Statistics for Various Values of Input R/N.(U)

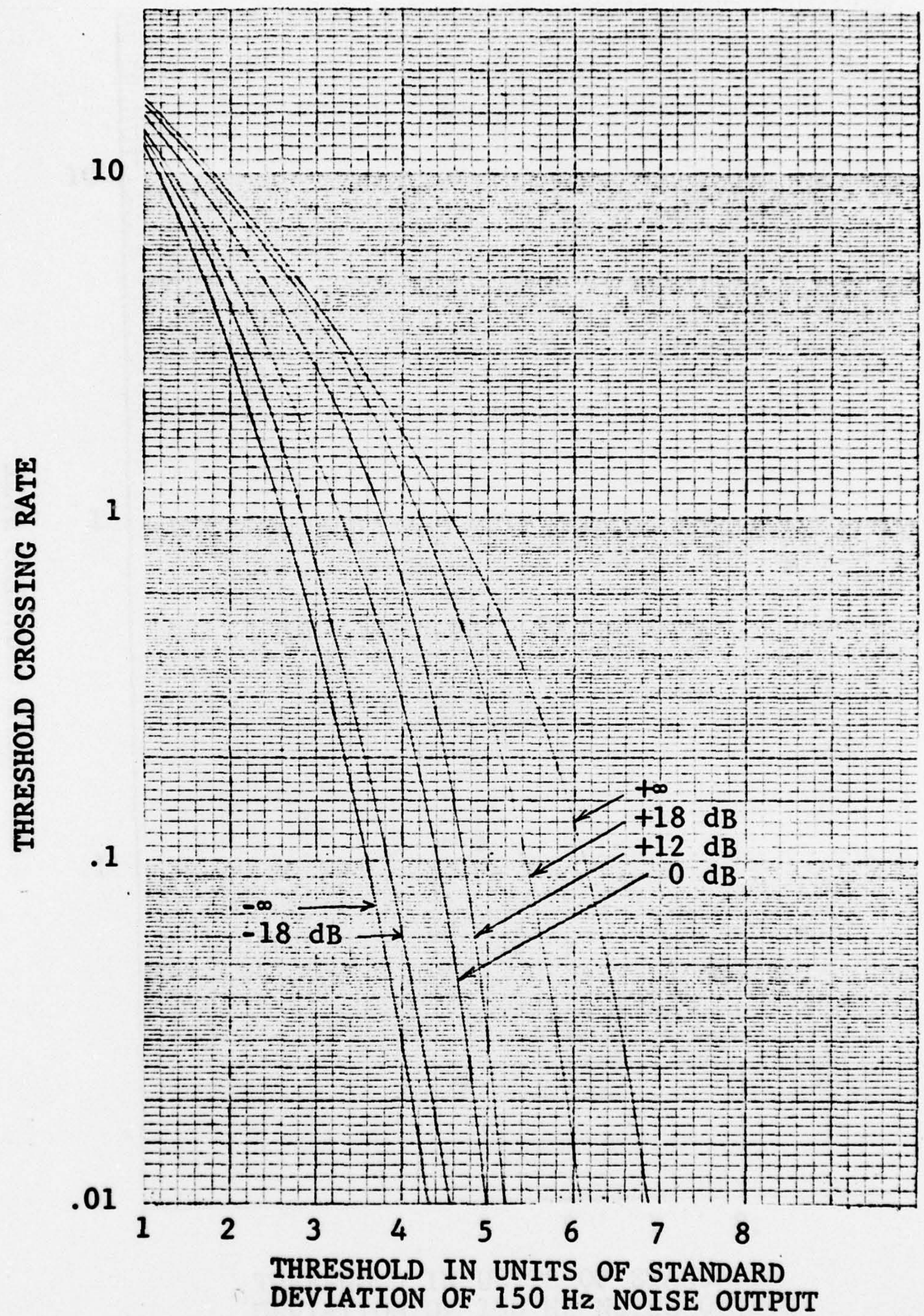

Fig. 6. ODT Mean-Divider Output Clutter Statistics for Various Values of Input R/N. (U)

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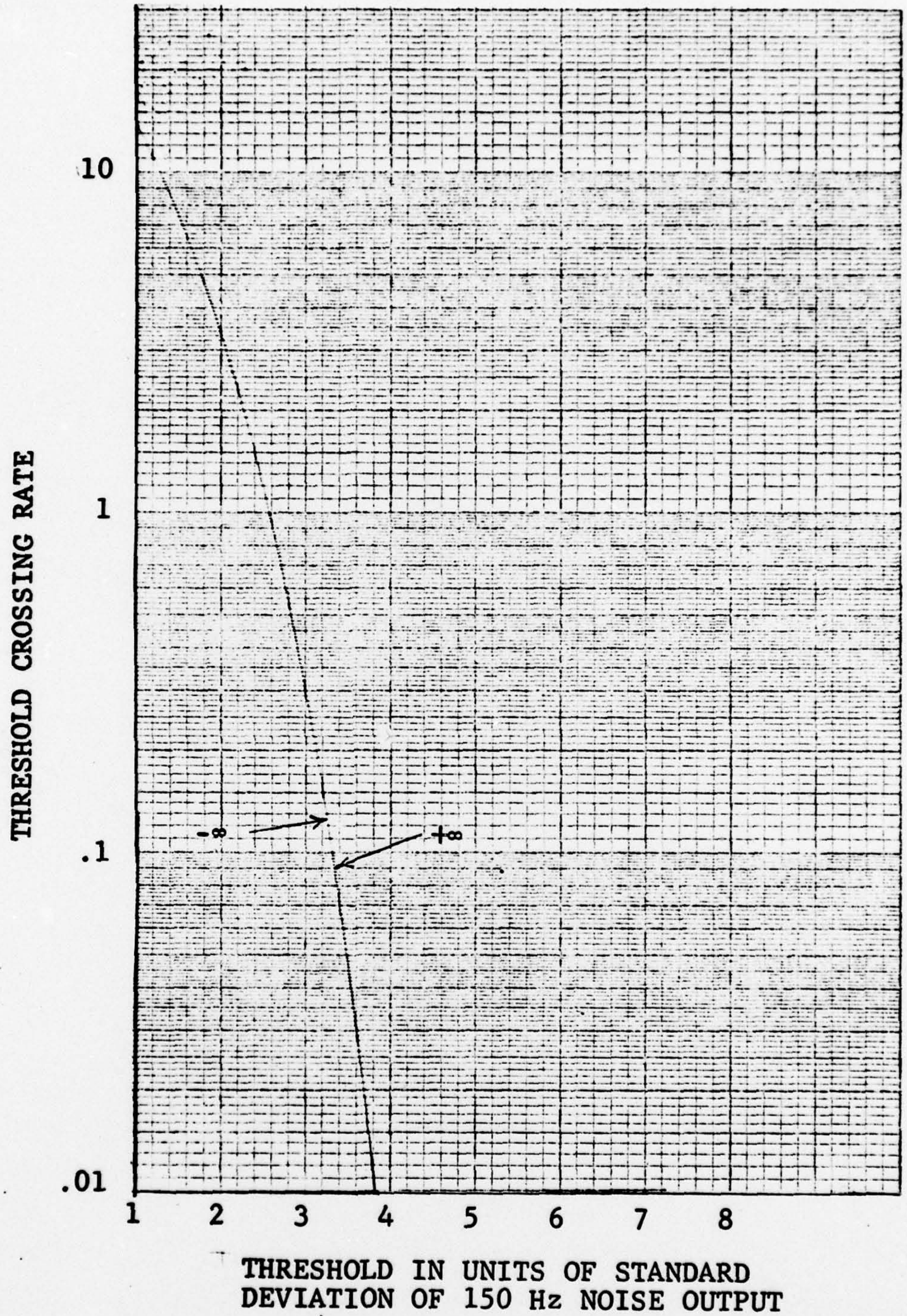

Fig. 7. ODT Norm Device Output Clutter Statistics for All Values of Input R/N. (U)

4.3 PROCESSING GAIN MEASUREMENTS

(C) The results in the previous two sections indicate that the norm device is effective in reducing variations in the ODT channel output noise statistics. To insure that this gain is not offset by a degradation in signal detectability, processing gain curves were obtained for the base processor, the norm device, and also the mean-divider for three types of input interference. The noise alone case is shown in Fig. 8, reverberation alone is shown in Fig. 9, and reverberation plus noise in equal parts appears in Fig. 10. In Figs. 8 and 9 the theoretical processing gain curve is shown as a solid line. For Fig. 10 it is known that the theoretical processing gain curve should lie between the two theoretical processing gain curves shown in Figs. 8 and 9. The average of these two curves is given as an estimate of the theoretical processing gain curve for reverberation plus noise in equal parts.

(U) In determining the processing gain curves for the three cases above, twenty signals were added to the appropriate input interference at each of the input signal-to-noise ratios of 0, 2, 4, and 6 dB. Below 0 dB input signal-to-noise ratio, twenty signals are not a statistically adequate sample. The twenty signals were spaced at 780 msec intervals to insure they were added to independent interference. The signals plus interference were processed through the simulated ODT processor and the output signal-to-noise ratio was determined from

$$(S/N)_{out} = 20 \log \frac{P-\mu}{\sigma} \qquad (4\text{-}3)$$

where P is the average of the twenty peaks in the output, μ is the output mean for interference alone, and σ is the output standard deviation for interference alone.

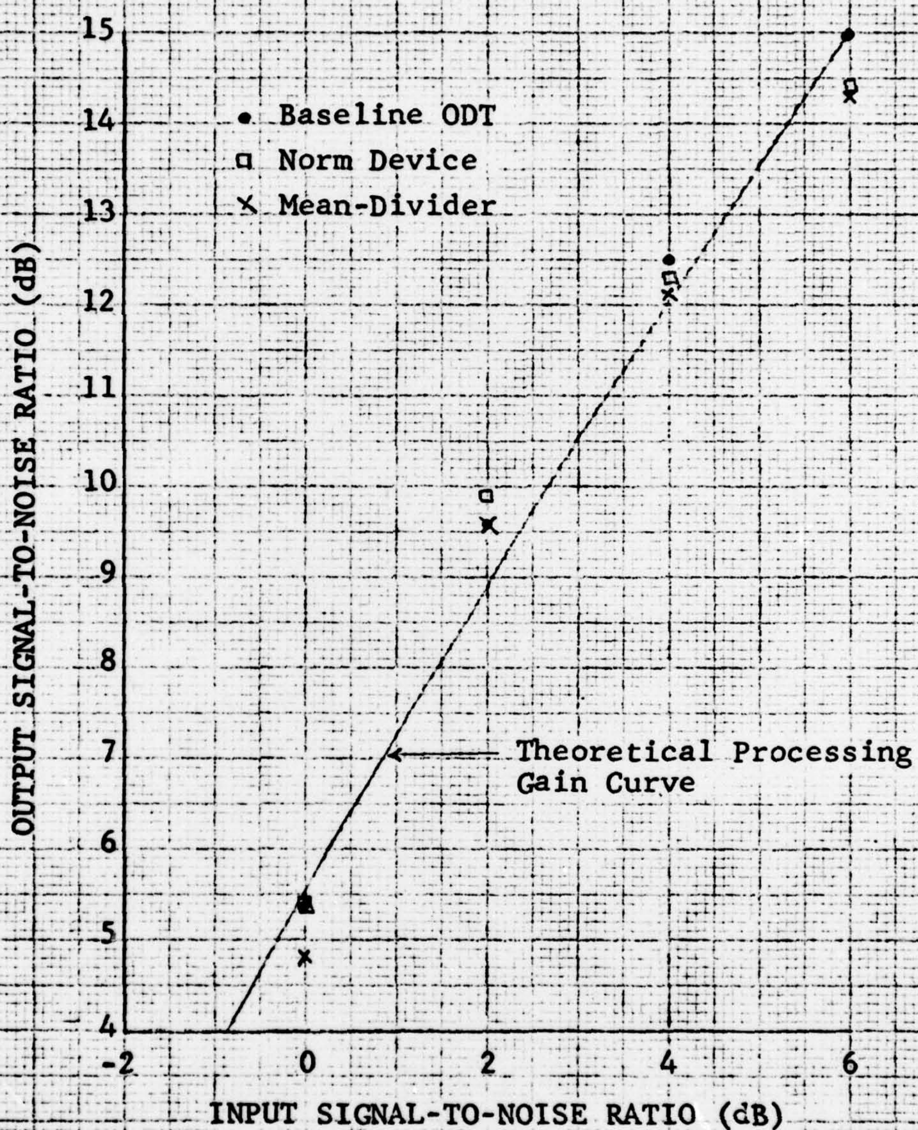

Fig. 8. Processing Gain Curves for 150 Hz Noise Alone. (C)

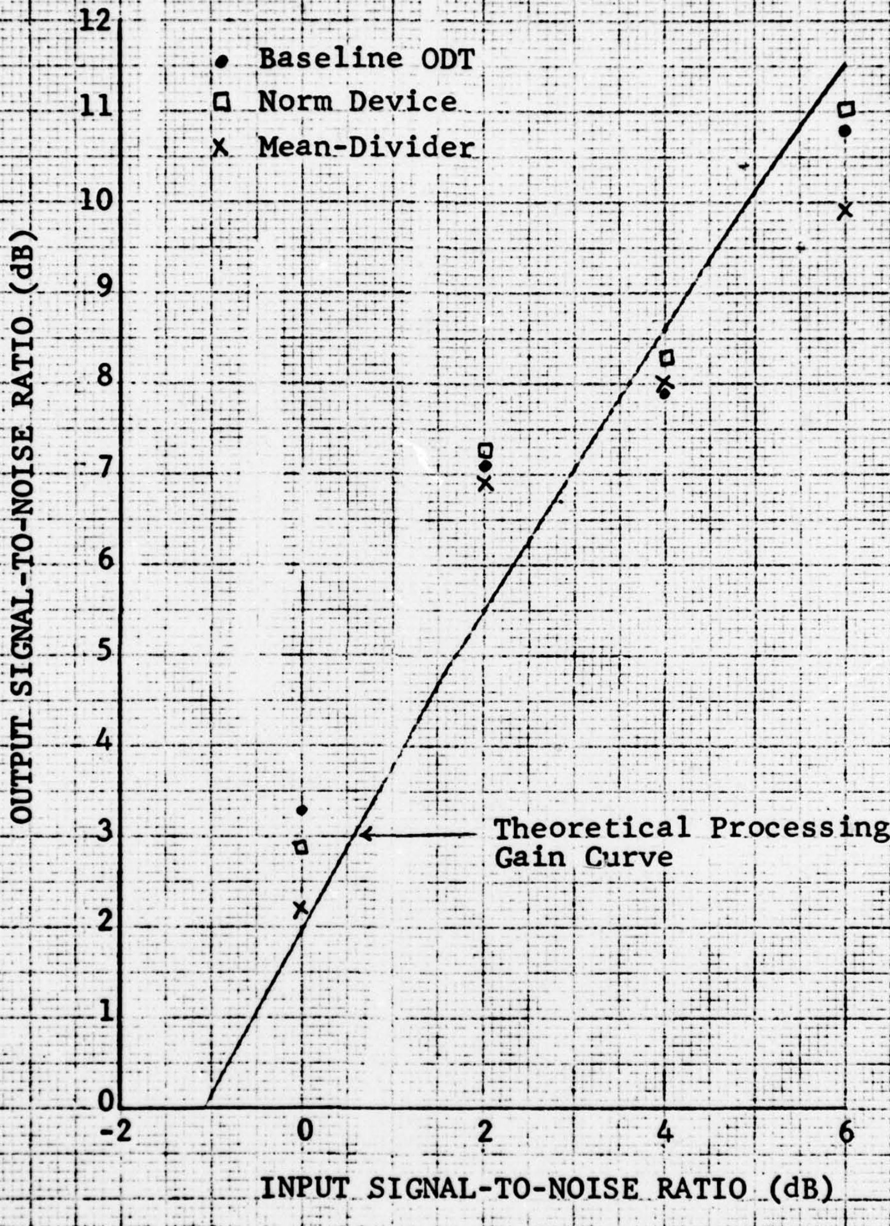

Fig. 9. Processing Gain Curves For Reverberation Alone. (U)

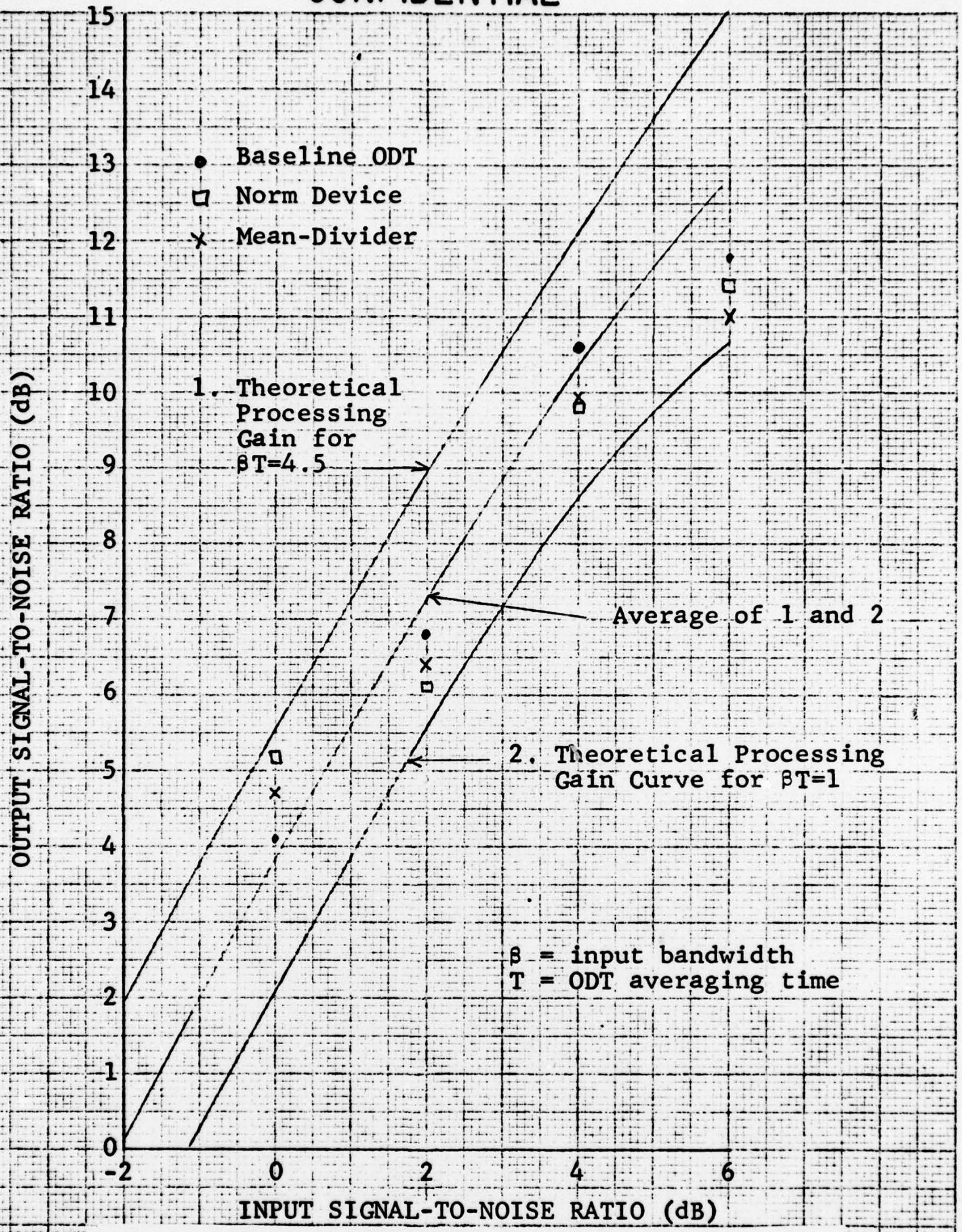

Fig. 10. Processing Gain Curves for Equal Parts of Reverberation and Noise. (U)

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~~(C)~~ (U) The output of the ODT processor was then passed through the norm device and the mean-divider respectively. The output signal-to-noise ratios for the norm device and the mean-divider were computed according to Eq. (4-3). The output signal-to-noise ratios as a function of input signal-to-noise ratio are plotted for the base processor, the norm device, and the mean-divider in Figs. 8, 9, and 10. Since the points are approximately equal in all three cases, it is concluded that neither the norm device nor the mean-divider degrades signal detectability on the ODT channel.